as given by Mr. Willcock in U. S. Weather Bureau Bulletin No. 11, with the monsoon rainfall in India. The tabular data for this purpose are probably not directly comparable, but the suggested connection is plausible and very important, as we shall thus be able to connect the famines of Egypt and India with the movement of the air over the equatorial regions.

The suddenness with which the southwest monsoon bursts over India may be compared, in many respects, with the advance of those sudden changes of the weather with which we are familiar in America. The blizzards and cold waves of the United States and the pamperos of Brazil advance with well-defined fronts, and effect a complete change in the weather at any place within a few hours. From a mechanical point of view the most interesting feature is the steady increase of pressure in the southern Indian Ocean while the air over India becomes hotter with a relatively slight decrease of pressure. The intervening atmosphere thus passes through a stage of unstable equilibrium, but as soon as the gradient of pressure sets decidedly northward the air begins to move accordingly, and under the steady action of this gradient its motion is accelerated until the pressures are just able to overcome the resistance. When the advance of the southwest monsoon has brought it to the coast of Hindustan a decided increase of resistance is experienced, which holds it back for several days. J. Allan Broun, the founder of the mountain station, Augustia, has graphically described the view of this contest between the monsoon wind and the resisting land. (See Trevandrum Mag. Obs., Vol. I, p. 517, or Baird's Annual, 1876, p. 102.) In a week or so the increase of pressure in the south and the increasing temperature have combined to overcome this resistance, and the southwest wind pours over the Ghats into the interior of the country. The monsoon advances more rapidly over the interior than it formerly did over the ocean because this delay has given opportunity for an increase in the pressure gradients that determine its motion.

Phenomena similar to the bursting of the monsoon may undoubtedly be found developed, but perhaps on a smaller scale in any country where sudden changes from dry to moist weather occur, and Capt. D. Wilson-Barker points out that it is well known under other names in the Soudan and in Australia.

The pamperos of South America and the northers of the United States illustrate the case of large masses of air advancing horizontally against resistances which must be overcome by an accumulation of pressure in the rear. As the motions over land are resisted far more than over the ocean by the irregularities of the surface, and by the topsy-turvy movements during the warmer part of the day, therefore the accumulation of pressure in the rear or in the so-called area of high pressure, must be larger than in the case of the southwest monsoons of India. The southerly burster of eastern Australia seems to offer an analogous case.

From the essay on Southerly Bursters, by Henry A. Hunt of the Sydney observatory, it would appear that these occur most frequently during the warmer half of the year in the Southern Hemisphere, viz., from September to March, the maximum being in December. In all cases these bursters occur between an area of high pressure, south or west of Australia, and a low pressure, usually a deep depression, north or east of Australia. The high pressure is advancing toward the east or northeast, and the low pressure frequently stretches into a long trough or oval. If we compare these conditions in the Southern Hemisphere with those that occur in the northern, we find a mechanical similarity between the southerly winds of the burster and the northerly winds of our cold waves and blizzards. The principal difference is that due to temperature; for whereas our high pressures and northers occur in our winter season, and represent dry cold air flowing toward a warm moist region, the Australian burster occurs in the southern summer and represents cold moist air from the southerly ocean flowing over a continent where the air is dry and hot. In the American norther the surplus density of the northerly winds is due to their own dryness and low temperature, whereas in the Australian burster the surplus density of the southerly winds results from the deficient density of the very hot dry air over that continent. As the Australian continent is of about the same area as the United States, but has its center of figure about ten degrees nearer the equator, therefore, its average summer temperature is higher than ours. As it has no land to the south corresponding to the Dominion of Canada, therefore in its winter season it is colder than the Polar Ocean in its immediate neighborhood, but in its summer season its temperature is very much hotter than that of its Polar Ocean. Hence, Australia has no great winter blizzards, but has its southerly bursters in the summer time. The severity of the southerly or polar winds in Australia is modified very much by local conditions; thus, in western Australia the winds pass over comparatively level country, but in the eastern portion, the province of New South Wales, is traversed by a mountain range that checks the forward motion of the air until the increasing high pressure carries it over. In the basin west of these highlands the plains are highly heated by the sun and the hot surface air acquires a topsy-turvy circulation, until the high pressure on the west has accumulated sufficiently to push the air eastward over the coast range, which it accomplishes suddenly, while at the same time the southerly winds on the coast rushing inward produce the local gale at Sydney, known as a brickfielder or southerly burster. On the whole the burster is unfavorable to rain; it may bring a few showers to the coast but dry weather prevails in the western part of Australia. A well-developed area of high pressure, such as gives a typical southerly burster, lasting three days, has an axis extending 2,400 miles north and south, and it travels at the rate of 400 miles per day. Steady breezes attend it during the six days required by it to travel from west to east over the lowlands of Australia.

The areas of high pressure that bring bursters to Australia are but special single areas out of hundreds that pursue similar courses over the Antarctic Ocean, but do not happen to approach Australia. Their development and progress constitute integral parts of the so-called general circulation. Special features in the phenomena of bursters are due to local Australian conditions, but the general character of the high areas and the resulting general features of the bursters must be studied not in Australia, but over the distant oceans.

THE PRESENT CONDITION AND RECENT PROGRESS OF CLIMATOLOGY.

By Prof. Dr. W. KOEPPEN. (Extract from Geographische Zeitschrift, Vol. I, p. 617, etc.)

"In America there exists a well-organized system of observations. Notwithstanding this the study of the climatology of this continent is still beset with many difficulties. The extensive system of the U. S. Signal Service that is supplied with money to an extent entirely unknown for such purposes in Europe was originally so trimmed down to the needs of weather telegraphy and weather predictions that there was remarkably little left for climatology or even for science in general. Generals Hazen and Greely, the successors of General Myer, on the other hand, brought about a change by the introduction of scientific investigations, which, after 1891, found a wider official recognition in the transfer of this branch of the public service from military hands over to the Department of Agriculture. Even now, however, practical applications play the leading part in the programme of the new Weather Bureau, but among these the establishment of the climatic elements takes a prominent place. The treasures of observations and self-registers that have accumulated in a

quarter of a century are now made accessible to scientific students more and more freely by a series of important publications and especial care is taken for the rapid and full publication of the data in monthly and annual publications. These publications, especially the MONTHLY WEATHER REVIEW, are now much richer in detail than before and have, indeed, become an authority of the first rank that is, as yet, but little used."

Of meteorology Koeppen says, page 619:

The investigation of the upper strata of air, which has been prosecuted in the last decennium more than ever before, has excited lively interest. Perhaps, in so far as this study has been prosecuted in the free atmosphere rather than at mountain stations, we ought to reckon it as climatology; but if climatology is not to confine itself to the simple facts that can be observed at the earth's surface, but is to take cognizance of their interrelations, it is impossible to ignore what is going on above our heads. It is evident that the air which surrounds us is greatly influenced by whatever goes on within the atmosphere at a short distance. We must not forget that within from 2 to 10 kilometers above us we find entirely different conditions as to temperature, moisture, wind, and pressure, and that from these altitudes there descend upon the earth's surface masses of air that are sometimes very large, at other times very small.

Already, between 1870 and 1880, many high stations, with meteorological observatories, were established in North America and in France. These costly establishments have, unfortunately, advanced science but little, simply because the observations were not published and discussed in a satisfactory manner. The two American stations—located most admirably, Mount Washington and Pikes Peak—were established in 1873, less for the advancement of science than for practical use in weather predictions, although, for want of a scientific knowledge of the upper strata of air, one really did not know how to utilize these observations for predictions. On account of the great expense, especially that of the maintenance of the telegraph lines, these stations are at present abandoned. Pikes Peak, the highest station on the globe (4,300 meters above the sea), ceased observations in 1888, and the daily telegrams ceased in 1882. In order to save its records for the use of science, the observatory of Harvard College published them, in 1889, as Vol. XXII of its Annals. In September, 1892, hourly observations were begun on Pikes Peak and at the base station, Colorado Springs, but, in 1894, these were again closed "for want of money," and that, too, on a mountain that has a steam cog-wheel road to the summit! On the snowy Alps the telephone on the Sonnblick works without failure over the glaciers and at very little expense.

With regard to dynamic meteorology Koeppen says (page 625):

Another important series of ideas that has only recently been introduced into the scientific study of the atmosphere is the application of the theory of wave motions. On the one hand Helmholtz has made it seem probable that progressive waves are formed at the boundary between two currents of air of different velocities superposed upon each other, and that these play an important part in the nonperiodical phenomena, such as the formation of clouds, wind gusts, etc. One example of an atmospheric wave was, in fact, followed many times around the whole earth even before Helmholtz wrote, namely, in the case of the wave attending the outbreak of Krakatoa on the 27th–31st August, 1883. On the other hand from the empirical investigations of Hann and Greely and the mathematical analyses of Lord Kelvin, Margules, and A. D. Schmidt it results that the solution of the riddle of the daily barometric variations will, probably, be found in the formation of stationary waves in the atmosphere in consequence of the diurnal change in temperature. The result of the comprehensive investigation by Hann on this subject consists, especially, in the clear distinction between the daily double variation of pressure depending upon the geographical latitude, almost entirely, and the single variation connected therewith, which latter depends upon the earth's surface and the weather. The discovery of Greely (Lady Franklin Bay Vol. II, p. 169) and A. D. Schmidt (Met. Zeit., 1890, p. 182) consists in this that in the Polar regions the diurnal barometric variation depends not upon the time of the local meridian, but upon a common time evidently that of the region in the interior of Asia having the greatest daily variation. It is thus clear that here we have to do with waves whose causes prevail, not at the place itself, but at a great distance therefrom. Such a diurnal variation which depends upon the time of a distant locality reminds one of the annual variation of the pressure of the air over the oceans of the Southern Hemisphere, which rises and falls simultaneously with the rise and fall of the air pressure over the oceans of the Northern Hemisphere notwithstanding the opposing seasons. The explanation of this lies in the annual transfer or interchange of masses of atmosphere between the Northern and Southern Hemispheres, as I first showed in 1879 (Annalen d. Hydrographie, p. 510, and in the Met. Zeit., p. 417).

"We can not close without mentioning one of the fundamental questions of climatology with which many investigators have busied themselves during the past decade, namely, the questions as to the general circulation of the atmosphere or the wind systems of the globe. During the first sixty years of this century meteorologists necessarily studied the geographical connection of atmospheric processes by means of observations at the individual stations and by the comparison of mean values at different stations. In these sagacious combinations the general system of motions of the earth's atmosphere played an important part. By reason of the new views which the synoptic treatment of simultaneous weather conditions by means of charts and tables allowed, attention was especially called, between 1860 and 1880, to the individual phenomena and the pursuit of their consequences over portions of Europe and America. From these investigations there resulted the important studies on the movements of the atmosphere that were published by the Norwegian professors Guldberg and Mohn, 1876–1880, and which gave the impulse to the applications of hydrodynamics to these motions. Then it was discovered with surprise that already, in 1859, the American meteorologist, Ferrel, had treated of this subject in a brilliant manner and that he had also included the general system of atmospheric circulation between the pole and the equator in the series of his discussions and approximate calculations. Ferrel's theory as to this general circulation is explained with some supplementary details in the excellent treatise on meteorology by Sprung, published in 1885, pp. 192–208. Since that time the question as to the circulation there explained has not been materially advanced so far as meteorology is concerned; but Professor Oberbeck has given another treatment, mathematically more correct, that agrees with Ferrel's results and with experience if we assume that the current which Oberbeck calls the lower current (U) does not reach down to the earth's surface; otherwise Oberbeck's theory is contradictory to both Ferrel and nature.

"The phenomena at the earth's surface itself which Ferrel has taken into consideration are entirely passed over by Oberbeck. The investigations of Max Moeller and Teisserenc de Bort upon these subjects adhere more closely to experience.

"In Germany the question of the general circulation of the atmosphere was first considered outside of the narrow circle of specialists when the renowned physicist and manufacturer, Werner Siemens, in 1886, published an article on this subject in the Sitzungsberichte of the Berlin Academy. This and some further articles that Siemens published on this subject agree with the meteorological facts to a far less extent than Ferrel's work, which latter was also much more completely developed. It is the duty of the present reviewer to state this fact, since those who live at a distance, ordinarily, had much rather follow the leadership of a distinguished foreigner, or outsider, than the less well-known specialist in the respective lines of work, and even inside the ranks of the specialists the influence of so genial a man is very considerable. Thus, Pernter believes that the conclusion of Siemens that even in the higher portions of the atmosphere easterly winds prevail between 35° north and south, finds a support in Oberbeck's calculations. This error undoubtedly arises from an oversight, and in the Met. Zeit. for 1890, the anti-trade is defended with success by Sprung. In the same volume Siemens, in his reply on page 324, then presents the entirely false idea that horizontal differences of temperature give no basis for motions of the atmosphere, but that only an excess of temperature in the lowest strata above the adiabatic distribution of temperature, in the vertical direction, can cause such movements. In reality, even in the cases where the vertical distribution of temperature really responds to unstable equilibrium (which latter is ordinarily caused not by temperature alone, but with

the assistance of other forces arising from the motion of the air and the rotation of the earth) the horizontal differences of pressure arising therefrom are the active forces, as I, among others, have explained in the Austrian Z. O. G. M., 1882, p. 91, where (in the foot-note) I have warned against the too frequent overestimation of the influence of the warming of the air at the base.

"We have thus come to the limit where the geographical element is less important than the physical; where climatology passes over into meteorology. Of course, however, climatology is in the highest degree interested in the progress of meteorology since the connection between its individual isolated facts is in great part to be expected from it. Especially is it true that the explanation of the nature and development of atmospheric whirls or, the regions of high and low pressure, their changes with altitude, their origin and disappearance, will be of the greatest importance for climatology as well as for meteorology. Our knowledge of the movement of whirls has made good progress, but as to their changes in intensity we know nothing except some isolated empirical rules and many vague assumptions. In order to make further advance in this matter we need, above all, a more accurate insight into the distribution of temperature and pressure in the higher strata above cyclones and anticyclones. About five years ago Hann published the sensational discovery that in the Alpine region in anticyclones, notwithstanding the great cold at the surface of the soil, the mean temperature of the column of air between this ground and the level of 3,100 meters above the sea, was higher in the centre of anticyclones than in cyclones. A further extension of this investigation to other portions of the world promises further important conclusions. In such work observation and study must go together in order to further the advancement of science."

FOG IN NEW YORK HARBOR.

Owing to the clear sky that prevails within areas of high pressure the radiation of heat from the ground or the ocean surface and from the lowest stratum of air, proceeds more rapidly and, as is well known, during such periods mist and fog are formed in the lower air. Radiation proceeds uninterruptedly during the night time from the upper surface of foggy air and the depth of the layer of fog steadily increases, so that oftentimes the heat of the sun, in the middle of the day, is not sufficient to dissipate the fog formed at night. It has often been remarked that the lookout at, or above, the main top overlooks the ocean of fog. In general, a dense fog implies clear sky above it and by attention to the movement of areas of pressure it becomes possible to predict fog on our coast.

On Tuesday, December 17, and Wednesday 18, high pressure prevailed off the middle Atlantic Coast with northeast winds shifting to southwest at New York, N. Y. During Tuesday night and the greater part of Wednesday dense fog prevailed in both the upper and lower bay; the Sound steamers did not attempt to come through Hell Gate; the ocean steamers were detained below quarantine; nothing could be seen at Sandy Hook and all movements were guided by the sound of the fog signals. This fog was attributed by some to the unseasonably warm weather prevailing all along the neighboring coasts. The extreme temperatures were as follows:

Locality.	17th.		18th.	
	Min.	Max.	Min.	Max.
	°	°	°	°
Nantucket	32	36	32	50
New York	26	42	34	48
Philadelphia	26	44	34	50
Atlantic City	24	.....	38	.....

These figures do not show any temperatures that are unusually high for this region, neither is the occurrence of fog unusual at this season; it is, in fact, the ordinary accompaniment of areas of high pressure in the winter time over the ocean.

SNOWFALL IN NORTH DAKOTA.

With regard to the snowfall in North Dakota, Mr. B. H. Bronson, in his November bulletin says:

The principal feature was the unusually early fall of snow, which became general over the State by the 5th instant, and was very heavy in many localities. Old settlers in this section remark that this early snow is the earliest that has occurred during their residence here, and has rendered the hauling of grain by sleds more practicable than by wagons. The snowfall promises an abundance of moisture for the ground when the spring plowing shall commence, but at the present time it renders the pasturage very poor, as the cattle are unable to get at the grass and low herbage. The snowfall is greatly appreciated as it prevents the further destruction of crops and property by prairie fires. The observer at Fort Berthold, in McLean County, reports the pasturage in that section as the poorest in many years, on account of the recent prairie fires, which have also devastated many other sections of the State.

METEOROLOGY AND LOCAL STATE FAIRS.

The need of personal acquaintance between the voluntary observers and the directors of the respective State services is alluded to in the Weather and Crops for January, 1896, by the director of the Illinois Service, and he states his intention to provide for such a need at an early date. On several occasions the presence of some official of the Weather Bureau at a county fair, a State fair, or a general exposition has been productive of many advantages to the Weather Bureau observers who attended such meetings. This was notably so in the case of the expositions at Atlanta and Chicago. In general, State fairs offer an important means of exhibiting, day by day, to crowds of visitors the methods of observation pursued by the Weather Bureau and the numerous ways in which its work can be made useful to the people. In recognition of this general principle a special "Board on Expositions" has been organized at the Central Office, and instruments or publications that are appropriate for exhibition will, it is hoped, always be kept on hand ready for use.

POSSIBLE ADVANCES IN THE WEATHER SERVICE.

We make the following extracts from an excellent address by J. R. Sage, published in the current number of the Iowa Monthly Review:

The weather has been the subject of daily observation and remark in all ages, yet the science which undertakes by rational and philosophical methods to account for the varied phenomena of the atmosphere is comparatively new. By far the greater portion of all that has been achieved in the solution of the intricate problems relating to the weather has been wrought out within the latter half of the nineteenth century. The Weather Bureau, including the State branches, was instituted to serve the people, and to do this efficiently it must be progressive, and the advances that are not only possible, but also most desirable, should be along educational and practical lines. There is need of popularizing the science of meteorology, and more widely disseminating a knowledge of the salient facts that have been learned in this new field of investigation. * * * The special need of this age is science made popular and widely disseminated. To this end there is need of workers and students in this field who are in close touch with the common people and who are able to translate the most scholarly and profound scientific writings into the language of ordinary people. The scientific lore of this age can not be shut up in cloisters nor monopolized by favored classes, but must be scattered broadcast to take root and bear fruitage in the world. I am glad to make note of the fact that the Weather Service is doing excellent work along the line of popular education.

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In practical horticulture success depends absolutely upon adaptation of plant or tree to the climate. And the Weather Service should furnish the necessary data for the study of the effects of climate upon all classes of vegetation.

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For the advancement of both horticulture and the Weather Service, a more close and intimate relation should be established between them.